

Claims

1. In a system that allows the autonomous control of a small unmanned helicopter, an autonomous control system for a small unmanned helicopter comprising:

sensors that detect the current position, the attitude angle, the altitude relative to the ground, and the absolute azimuth of the nose of said small unmanned helicopter;

a primary computational unit that calculates optimal control reference values for driving the servo motors that move five rudders on the helicopter from target position or velocity values that are set by the ground station and the aforementioned current position and attitude angle of the small unmanned helicopter that are detected by the aforementioned sensors; and

a secondary computational unit that converts the data collected by said sensors and the computational results as numeric values that are output by said primary computational unit into pulse signals that can be accepted by servo motors.

2. In a system that allows the autonomous control of a small unmanned helicopter, the autonomous control system for a small unmanned helicopter of Claim 1, wherein said sensors, said primary computational unit, and said secondary computational unit are assembled into a small frame box, thereby achieving both size and weight reductions that permit the mounting of the frame box on said small unmanned helicopter.

3. In a system that allows the autonomous control of a small unmanned helicopter, the autonomous control system for a small unmanned helicopter of Claim 1, wherein the system has a ground station host computer that has the same functionality as said primary computational unit and wherein the autonomous control system can also use said ground station host computer as it performs said autonomous controls as necessary.

4. In a system that allows the autonomous control of a small unmanned helicopter, the autonomous control system for a small unmanned helicopter of Claim 3, wherein when using said ground station host computer as the primary computational unit for the performance of said autonomous controls, the autonomous control system outputs the

computational results that are output by said ground station host computer to said servo motors through a manual operation transmitter.

5. In a system that allows the autonomous control of a small unmanned helicopter, the autonomous control system for a small unmanned helicopter of Claim 4, wherein when said ground station host computer is used as the primary computational unit for the performance of said autonomous controls, for the process of directing the computational results that are output from said ground station host computer to said servo motors through a manual operation transmitter, the autonomous control system is equipped with a pulse generator that converts said computational results as numerical values into pulse signals that said manual operation transmitter can accept.

6. In a system that allows the autonomous control of a small unmanned helicopter, the autonomous control system for a small unmanned helicopter of Claim 1, wherein, for the performance of said autonomous controls, the autonomous control system is equipped with a servo pulse mixing/switching apparatus as an external device to said autonomous control system that receives control signals that are output by said primary computational unit through said secondary computational unit and that outputs them to said servo motors.

7. The autonomous control system for a small unmanned helicopter of Claim 6, wherein the servo pulse mixing/switching apparatus, on all said servo motors for said small unmanned helicopter, permits the switching of manual operation signals and said control signals that are output from said autonomous control system, or mixing thereof in any proportion.

8. The autonomous control system for a small unmanned helicopter of Claim 6, wherein the servo pulse mixing/switching apparatus shares the power supply system for said servo motors.

9. The autonomous control system for a small unmanned helicopter of Claim 6, wherein the servo pulse mixing/switching apparatus is equipped with a safety feature that automatically restores the computational unit for said switching and mixing that detects anomalies if an anomaly occurs in the computational unit for switching and mixing.

10. The autonomous control system for a small unmanned helicopter of Claim 6, wherein the servo pulse mixing/switching apparatus automatically recognizes the connection status of signal wires and whether or not a signal is present, and transmits appropriate signals to said servo motors based on the recognition.

11. The autonomous control system for a small unmanned helicopter of Claim 6, wherein the servo pulse mixing/switching apparatus is provided with a function that outputs manual operation signals that are input into said servo pulse mixing/switching apparatus to said autonomous control system.

12. The autonomous control system for a small unmanned helicopter of Claim 4 comprising: for the performance of autonomous control, a servo pulse mixing/switching apparatus as an external device to said autonomous control system that receives control signals that are output from said primary computational unit through said secondary computational unit and that outputs them to said servo motors;

wherein the servo pulse mixing/switching apparatus has the function of directing the output of manual operation signals, which are input into said servo pulse mixing/switching apparatus, to said autonomous control system, and wherein, using this function, the manual operation transmitter can be used as a target value input apparatus for autonomous control purposes.

13. The autonomous control system for a small unmanned helicopter of Claim 1, wherein the primary computational unit calculates optimal control reference values for the driving of servo motors that operate the rudders for the small unmanned helicopter and the primary computational unit performs tri-axial attitude control for said small unmanned helicopter.

14. The autonomous control system for a small unmanned helicopter of Claim 13, wherein the primary computational unit uses the following mathematical model for the transfer function representation including pitching operation input and pitch axis attitude angles in the tri-axis attitude control for said small unmanned helicopter:

$$G_{\theta}(s) = e^{-Ls} \frac{K_{\theta} \omega_{ns}^2}{(s^2 + 2\zeta_s \omega_s s + \omega_{ns}^2)(T_{\theta} s + 1)s} \quad \dots (13)$$

such that the primary computational unit calculates control reference values based on said model equation.

15. The autonomous control system for a small unmanned helicopter of Claim 13, wherein the primary computational unit uses the following mathematical model for the transfer function representation including rolling input and roll axis attitude angles for tri-axis attitude control :

$$G_{\phi}(s) = e^{-Ls} \frac{K_{\phi} \omega_{ns}^2}{(s^2 + 2\zeta_s \omega_{ns} s + \omega_{ns}^2)(T_{\phi} s + 1)s} \quad \dots (14)$$

such that the primary computational unit autonomously controls said small unmanned helicopter based on said model equation.

16. The autonomous control system for a small unmanned helicopter of Claim 13, wherein the primary computational unit uses the following mathematical model for the transfer function representation including yawing input and yaw axis attitude angles for said tri-axis attitude control :

$$G_{\psi}(s) = e^{-Ls} \frac{K_{\psi} \omega_{ns}^2}{(s^2 + 2\zeta_s \omega_{ns} s + \omega_{ns}^2)s} \quad \dots (15)$$

such that the primary computational unit autonomously controls said small unmanned helicopter based on said model equation.

17. The autonomous control system for a small unmanned helicopter of Claim 13, wherein the primary computational unit uses the following mathematical model for the transfer function representation including pitch axis attitude angles and longitudinal speeds in the translational motion control:

$$V_x = g \frac{T}{s + T} \frac{a}{s - a} (-\Theta) \quad \dots (16)$$

such that the primary computational unit autonomously controls said small unmanned helicopter based on said model equation.

18. The autonomous control system for a small unmanned helicopter of Claim 13, wherein the primary computational unit uses the following mathematical model for the transfer function representation including roll axis attitude angles and lateral speeds in the translational motion control:

$$V_y = g \frac{T}{s + T} \frac{a}{s - a} \Phi \quad \dots (17)$$

such that the primary computational unit autonomously controls said small unmanned helicopter based on said model equation.

19. The autonomous control algorithm for a small unmanned helicopter of Claim 13, wherein the primary computational unit uses the following mathematical model for the transfer function representation of vertical speeds in the translational motion control for said small unmanned helicopter:

$$V_z = \frac{k}{s} \Theta_t$$

... (18)

such that the primary computational unit autonomously controls said small unmanned helicopter based on said model equation.

20. The autonomous control algorithm for a small unmanned helicopter of Claim 13, wherein the primary computational unit autonomously controls said small unmanned helicopter by executing independent autonomous control algorithms on the six physical quantities of said small unmanned helicopter: pitch axis attitude angle, roll axis attitude angle, yaw axis attitude angle, longitudinal speed, lateral speed, and vertical speed.

21. The autonomous control algorithm for a small unmanned helicopter of Claim 13, wherein the primary computational unit autonomously controls said small unmanned helicopter by constituting the respective autonomous control algorithm as a type 1 servo system so that for the respective physical quantities of said small unmanned helicopter, the steady-state deviation from any target value will be zero.

22. The autonomous control algorithm for a small unmanned helicopter of Claim 21, wherein said small unmanned helicopter is autonomously controlled by applying either linear quadratic Gaussian (LQG) theory or linear quadratic integral (LQI) theory to the autonomous control algorithms that are constituted as a type 1 servo system, by treating the respective autonomous control algorithms as uncoupled transfer function representation mathematical models.

23. The autonomous control algorithm for a small unmanned helicopter of Claim 13, wherein the primary computational unit represents dynamic characteristics consisting of longitudinal speeds and lateral speeds as mathematical models for which pitch axis attitude angles and roll axis attitude angles are input quantities, and by calculating the respective attitude angles that are necessary for the effecting of arbitrary longitudinal and lateral speeds.

24. The autonomous control algorithm for a small unmanned helicopter of Claim 13, wherein the primary computational unit autonomously controls said small unmanned helicopter, in order to move the position of said small unmanned helicopter to an arbitrary

position, by representing longitudinal target values, lateral target values, and vertical target values as follows:

$$V_{xref} = \alpha(P_{xref} - Px) \quad \dots (19)$$

for a longitudinal target value,

$$V_{yref} = \alpha(P_{yref} - Py) \quad \dots (20)$$

for a lateral value, and

$$V_{zref} = \beta(P_{zref} - Pz) \quad \dots (21)$$

for a vertical target value.

25. The autonomous control algorithm for a small unmanned helicopter of Claim 13, wherein the primary computational unit for said autonomous control system treats the mathematical model for transfer function representation that describes the dynamic characteristics of said servo motors that are contained in said Equations 13 through 15 as

$$G_s(s) = \frac{\omega_{ns}^2}{(s^2 + 2\zeta_s \omega_{ns} s + \omega_{ns}^2)} \quad \dots (22)$$

by entering M-series signals (pseudo-white signals) into said servo motors, by applying a ptechnologies ial space identificaton method based on input/output relationships, by determining the unknown parameters ω_{ns} and ζ_s in Eq. 22, and by designing autonomous control algorithms based on those values.

26. An autonomous control program for a small unmanned helicopter, wherein the program

causes the primary computational unit for the autonomous control system for the small unmanned helicopter to execute the following steps and causes it to compute optimal control reference values in order to drive the servo motors for said small unmanned helicopter:

- a step that receives detection signals from sensors that detect the current position, attitude angle, ground altitude, and absolute nose azimuth of the small unmanned helicopter;
- a step that receives position or speed target values that are transmitted from the ground station;
- a step that determines optimal control reference values for driving the servo motors that move a plurality of rudders for said small unmanned helicopter from the current position and attitude angle for said small unmanned helicopter that are detected by said sensors; and
- a step that causes translational motion control and tri-axis attitude control on the small unmanned helicopter based upon the results of said computational processing.